1971

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THESIS

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March 1971

Approved for public release; distribution unlimited.

Information Transfer in 2-, 3-, and 4-Word Verbal Discrimination

by

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1971

ABSTRACT

Sixty Naval Postgraduate School students served in a verbal discrimination (VD) experiment with 2-, 3-, and 4-word items and presentation rates per item of 1.5 or 3.0 seconds. Half the items had similar and half, dissimilar words. Based on information theory, lists of different lengths were prepared for 2-, 3-, and 4-word items. The lists were equated for overall load at 20 bits of information. Performance was consistent with the equal-load hypothesis and a differential of two in the amount of information transferred was observed because of the rate factor. Analysis of variance of correct responses revealed significant effects for item length, presentation time, similarity, and trials.

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I. INTRODUCTION

Underwood and Freund (1969) have shown that learning difficulty varies as the number of choices in a verbal discrimination (VD) item are varied when the total number of items in a list are held constant. Zacks (1969) has demonstrated that the total learning time tends to be invariant over various conditions of practice for a fixed task load. These characteristics of VD learning tasks would seem to have much in common with the information analysis of communication tasks (Garner 1962). That is, the number of possible alternatives in any VD item could be readily quantified in terms of the amount of information contained in the item if the expected relative frequency (a priori probability) of choice of each word could be identified. The total amount of information in a list would then be the sum of the information contained in each item of the list. Similarly, the invariance of total learning time could be expressed quantitatively in information measures as the rate of information processing.

The information analysis of VD tasks with more than two items might also provide additional information over conventional methods of analyzing VD learning. Conventional methods quite often count the number of correct and incorrect responses and analyze them separately. Information measures, when the responses are summed over

individuals, provide information regarding the patterning of choices over all the alternatives considered simultaneously. That is, learning can be expressed as a reduction in uncertainty demonstrated by the deviation of choices from a pattern of random choices, which has the maximum uncertainty.

To present the VD learning in the framework of information theory requires a method of reinforcement that provides a constant amount of information over all tasks. If the conventional noncontingent reinforcement procedures are used, the designation of a correct response from a 2-word item would provide one bit of information, but the reinforcement provided by the designation of a correct response from a 4-word item would present two bits of information. This problem could be alleviated for the 4-word item, for example, by presenting the four words first and then presenting only one of the words to the subject and asking the subject whether it is the correct response. Another problem is created by this solution, however, since the subject can optimize his chances of being correct by always responding "no." The simple solution, therefore is contingent reinforcement using the anticipation method. In this procedure, the subject is presented the alternatives and he is positively reinforced only when he chooses the correct alternative.

To summarize, VD learning could be analyzed using procedures from information theory if the initial probability

of choice of each word in a VD item is known and only contingent reinforcement of correct responses is provided. Learning could then be analyzed as the reduction in uncertainty of the subjects' responses from the uncertainty initially present in the item. Ideally, it would be desireable to have all the choices in any item equally probable. In this case, the information content is defined simply

$$I = \log_2 N,$$

where N equals the number of words. A 2-word item would have one bit of information; a 3-word item, 1.585 bits; and a 4-word item, two bits of information.

Using the foregoing notions, this study will examine the learning of 2-, 3-, and 4-word VD items using two presentation rates. In addition, the effects of similarity of the words in an item will also be examined.

II. METHOD

A. WORD LISTS

Three word lists, one each for the 2-, 3-, and 4-word treatments, were constructed and constrained to a maximum uncertainty of 20 bits.[1] For the uncertainty level selected, lists of 10, 12, and 20 discrimination items were required for the 2-, 3-, and 4-word treatments, respectively. The lists are shown in Table I. In order for the words in each item to have an equal a priori probability of selection on the first trial, three criteria for word selection were used. First, only words that were considered to have a high background frequency for all subjects were used. These words were selected from categories having at least a .9 correlation over test subjects in the category norms for verbal items compiled by Battig and Montague (1969). Secondly, half of the items in each list was constructed from words from the same verbal category by using words with as close to the same frequency as possible. The remaining items used words matched by the same response frequency from two, three, or four different categories, depending upon the respective discrimination tasks. Finally, all words in a discrimination task were required to have

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[1] In order to maintain list compatability for similar and dissimilar words, the three word discrimination list contained 19.02 bits of uncertainty.

TABLE I

WORD LISTS FOR 2-, 3-, AND 4-WORD TREATMENTS

Two-Word Treatments

murder	wine*	juice	doll*
apple	river*	book	lake*
iron	yard*	nail	swim*
tea	coffee	temple	rock*
table	chair	cotton	salt*
mother	father	bus	gun*
cat	dog	water	door*
eye	head	car	train
foot	mile	red	blue
corn	bean	hour	minute

Three-Word Treatment

door	temple	water*
brother	mother	father
green	blue	red
lake	book	table*
cotton	hours	salt*
apple	knife	cat*
iron	yard	doctor*
eye	head	foot
minute	hour	second
hill	river	rock
boat	train	car
nail	oil	swim*

Four-Word Treatment

mother	sister	brother	father
door	private	temple	water*
eye	foot	nose	head
swim	nail	wine	oil*
yard	doctor	iron	book*
yellow	blue	green	red
lake	rock	river	hill
cotton	salt	house	table*
cat	murder	knife	apple*
year	minute	hour	second

*Denotes dissimilar word groups. First word in each item was used as the correct response word in the experiment.

essentially the same frequency in the Thorndike and Lorge (1944) general count. In this respect, nearly all words used had AA or A word frequencies. Thus, each item had words of approximately equal response frequency in the Battig and Montague norms and all words had relatively high frequencies of use in the English language. The latter characteristic is important from the point of view of frequency theory (Ekstrand, Wallace, and Underwood, 1966), which states that discrimination learning of frequent words is more difficult because of their high background exposure prior to the subject's participation in a VD experiment. The correct word within any item was designated by random selection.

Using as a basis for decision the results of Underwood and Freund's (1970) work in VD retention, it was felt that six presentations of each list would be of sufficient length to observe trends in the results. The order of items in each of the six trials was randomized, as was the word order within each item.

B. DESIGN

Each discrimination task was considered to form a 1 X 2, 1 X 3, or 1 X 4 matrix having a uniform a priori probability distribution for the first selection of any word in the matrix. All responses, right or wrong, were recorded and used to form the a posteriori distribution over the alternatives. Further, the experiment conformed to a 2 X 3 X 2 mixed factorial with two levels of presentation time (1.5 and

3 sec.). The three different item lengths, as described, were presented as a between subject variable, while the similar or dissimilar word groupings were considered as a within subject variable. Treating the similar and dissimilar word groupings as fixed on a per trial basis, resulted in a 2 X 3 X 2 X 6 fixed factorial for analysis of the trials or trends variance.

C. SUBJECTS

The 60 subjects used were graduate level students in the operations research curriculum at the Naval Postgraduate School. They were volunteers and randomly assigned to the six treatment groups.

D. PROCEDURES

All subjects, following an explanation of the subject's task and procedures, were individually run by presenting the word lists on a Lafayette high-speed memory drum. The discrimination item was presented for a presentation time of 1.5 or 3.0 seconds. A blank space appeared for a similar interval for the interitem interval. The subject announced the word he believed to be the right discrimination and was reinforced with the verbal response "correct" from the experimenter if the right word was chosen, otherwise, there was no response. No additional time was given between trials; i.e., the six trials were run without a break.

III. RESULTS

The results will first be analyzed according to the growth of correct responses, then an analysis in terms of information transfer findings will be made. The percent of correct responses per trial by item length and presentation rate is shown in Table II. A graphic presentation of these data are shown in Figure 1. The percent of correct responses per trial as a function of similarity is shown in Tables III and IV, and a graph of the 3-second presentation rate treatments is shown in Figure 2.

TABLE II

PERCENT OF CORRECT RESPONSES PER TRIAL BY ITEM LENGTH AND PRESENTATION RATE

Trial	4-Words		3-Words		2-Words	
	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.
1	29.0	30.0	33.3	34.1	48.5	46.5
2	28.0	41.0	43.3	46.7	54.0	64.5
3	32.0	42.0	41.7	65.0	55.0	76.0
4	34.0	55.0	55.0	65.0	64.5	79.0
5	42.0	62.0	50.8	73.3	66.0	83.5
6	40.0	69.0	60.0	82.5	76.0	87.5

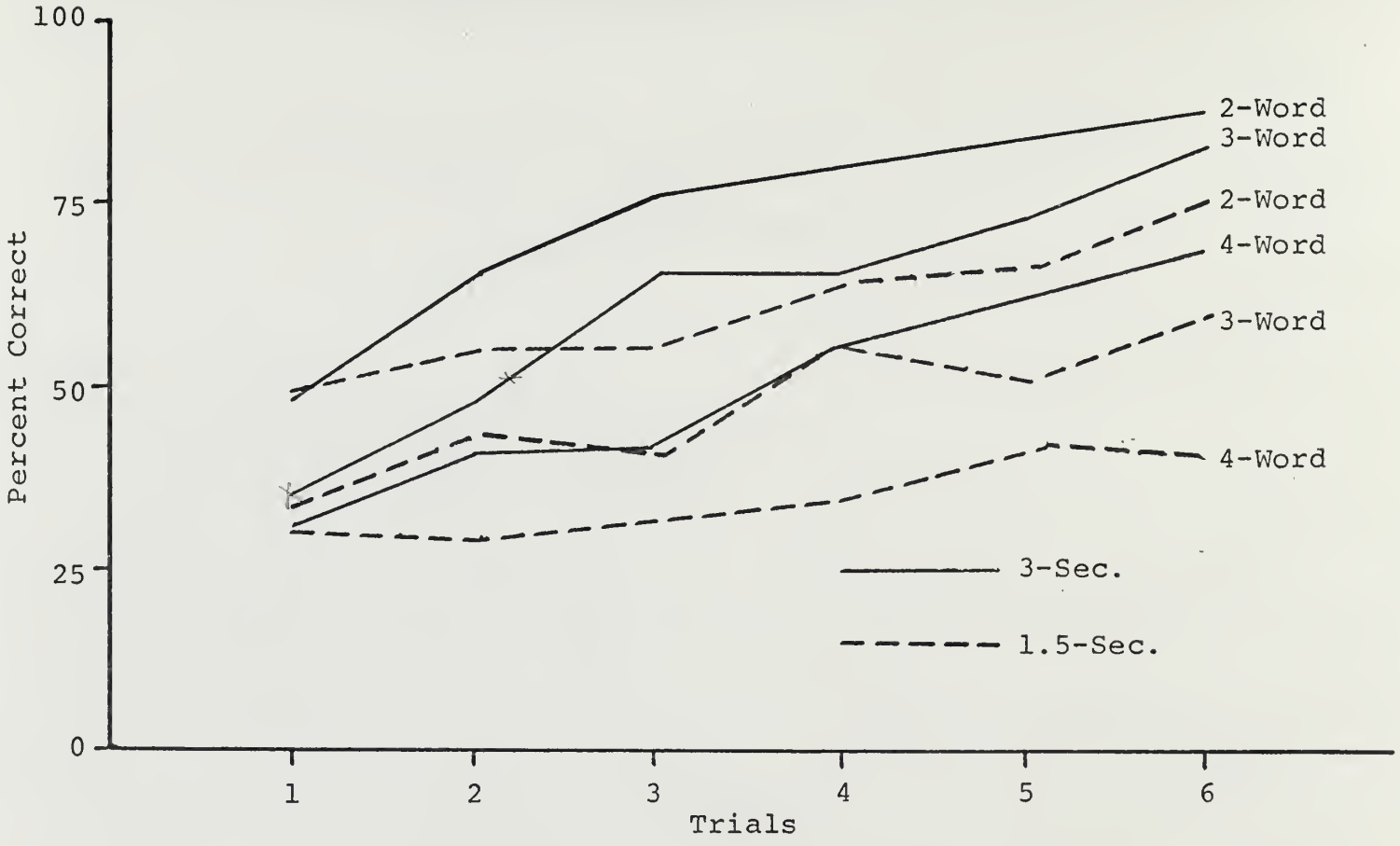

Figure 1. Percent Correct Responses for Each Treatment.

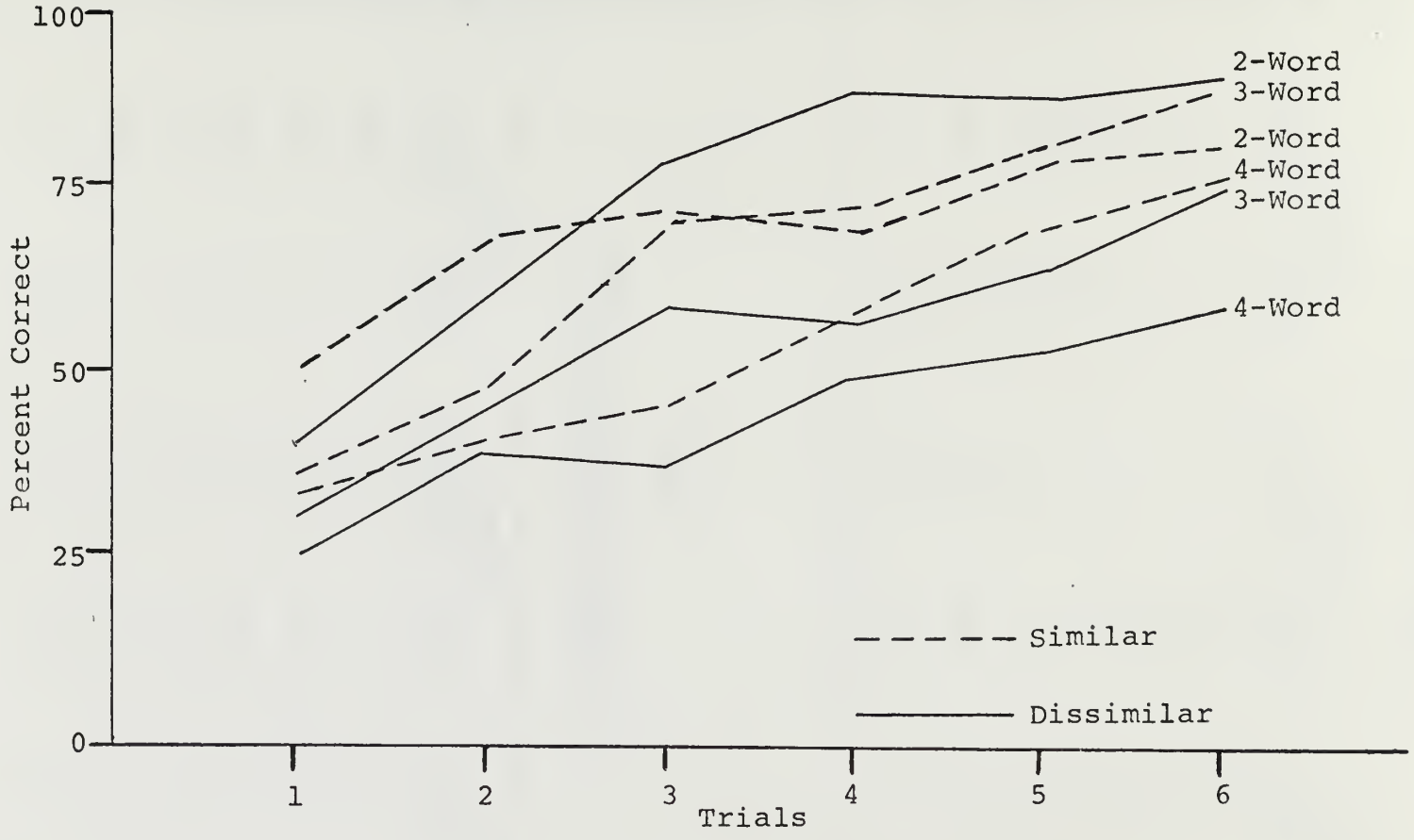

Figure 2. Percent Correct Responses for Similar and Dissimilar Words Over 3-Second Presentation Rate.

TABLE III

PERCENT OF CORRECT RESPONSES
FOR SIMILAR WORDS

Trial	4-Words		3-Words		2-Words	
	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.
1	32.0	34.0	33.3	36.7	48.0	52.0
2	26.0	42.0	45.0	48.3	55.0	68.0
3	30.0	46.0	43.3	70.0	57.0	73.0
4	44.0	60.0	55.0	73.3	67.0	70.0
5	46.0	70.0	58.3	81.7	60.0	80.0
6	48.0	78.0	65.0	88.3	71.0	83.0

TABLE IV

PERCENT OF CORRECT RESPONSES
FOR DISSIMILAR WORDS

Trial	4-Words		3-Words		2-Words	
	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.
1	26.0	26.0	33.3	31.5	49.0	41.0
2	30.0	40.0	41.6	45.1	53.0	61.0
3	34.0	38.0	40.1	60.0	53.0	79.0
4	26.0	50.0	55.0	56.7	62.0	88.0
5	38.0	54.0	43.3	64.9	72.0	87.0
6	32.0	60.0	55.0	76.7	81.0	92.0

The data were analyzed first using an analysis of variance over all subjects and all trials. Accordingly, item length and presentation rate were between subjects treatments and similarity was a within subject treatment. The results are shown in Table V. The main effects were all statistically significant, item length at less than the .001 level of probability and the similarity effect at less than .01. None of the interactions approached statistical significance.

TABLE V

ANALYSIS OF VARIANCE OVER SUBJECTS FOR ALL TRIALS

Source		df	MS	F
Between Subjects		(59)		
Word List	(A)	2	6213.02	31.92**
Rate	(B)	1	4953.68	25.45**
A X B		2	67.72	----
Error		54	194.60	
Within Subjects		(60)		
Word Similarity	(C)	1	1122.41	7.96*
A X C		2	93.26	----
B X C		1	7.00	----
A X B X C		2	198.27	----
Error		54	140.95	
Total		119		

*P $\leq$ .01
**P $\leq$ .001

In order to analyze trend effects across trials, an analysis of variance was conducted using nonrepeated measures. The basic datum for this analysis was the percent correct for each of 12 item length (3) x presentation rate (2) x similarity (2) treatments for each of six trials making a total of 71 degrees of freedom. The results of the analysis are shown in Table VI. None of the triple

TABLE VI

ANALYSIS OF VARIANCE OVER TRIALS

Source	df	MS	F
Word List (A)	2	3650.96	183.36**
Rate (B)	1	3430.68	172.31**
Similarity (C)	1	369.01	18.53*
Trials (D)	5	1655.84	66.31***
A X B	2	16.68	-----
A X C	2	244.35	4.45*
A X D	10	26.74	-----
B X C	1	26.65	-----
B X D	5	195.29	7.82**
C X D	5	8.88	-----
A X B X C[1]	2	19.91	-----
A X B X D[2]	10	34.21	-----
A X C X D[2]	10	54.94	-----
B X C X D[2]	5	11.50	-----
A X B X C X D[3]	10	24.97	-----
Total	71		

1. Error term of A, B, C.
2. Error terms for corresponding first order (2-way) interactions not involving D.
3. Error term for trials, the second order (3-way) interactions and the first order (2-way) interactions involving D.

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

interactions was significant when compared with the 4-way interaction. Accordingly, each was used as the error term as shown in the table for its corresponding main effects (less trials) and the 2-way interactions (less trials). The 4-way interaction was used as the error term for trials and the 2-way interactions involving trials. The results of the analysis show the effects for list length, presentation rate, and trials significant with a probability less than .01. The similarity effect was just significant at $p = .05$. Of the interactions, only the list length x similarity ($p \leq .05$) and the rate x trials effect ($p \leq .01$) reached statistical significance.

The analyses confirm what is evident in the performance curves of Figure 1. The amount learned is clearly dependent on the rate of presentation and, within each rate of presentation, the number of words in each item (item length). The significant rate by trials interaction confirms the apparent differences in the slope of the curves for presentation rate in Figure 1. The rate of learning is greater for the slower presentation rate. The reason why the similarity main effect is not clearly established in the trials analysis is given in the significant interaction of similarity by list length. It appears that similarity is a facilitative factor for three and four word items, but does not have this effect in the 2-word items.

The first step in the information transfer analysis was to compute the relative frequency that each choice was

selected on its first presentation. This was done as a check on the original assumption that each alternative or choice was equally likely to be chosen on the first trial. For the 2-word items, these probabilities can be obtained from Table II. For the 3-, and 4-word items, each word within an item was arbitrarily designated as word 1, 2, 3, or 4 (depending on the number of alternatives). The a posteriori probability for each classification is presented in Table VII for the 3-, and 4-word lists. Chi-square tests indicated that the null hypothesis of equal (random) choice of the alternatives could not be rejected ($p > .2$). Thus, the assumed prior distribution is upheld by the empirical results (posterior distribution). To recapitulate, each 2-word item had one bit of uncertainty; each 3-word item, 1.585 bits of uncertainty; and each 4-word item, two bits of uncertainty. The 2-word and 4-word lists had 20 bits of uncertainty, and the 3-word list, 19.02.

To compute information transfer, the next step was to determine the distribution of choices for each item on each

TABLE VII

POSTERIOR DISTRIBUTION OVER WORD LISTS OF 3-, 4-WORD ITEMS

	Word 1	Word 2	Word 3	Word 4	Chi-Square
4-Word Items	28.0	27.0	21.0	24.0	1.20
3-Word Items	33.3	36.0	30.4	--	.47

trial. Once this was accomplished, it was then a simple matter to obtain the uncertainty for the item set using tables of

$$U(x,y) = -\Sigma_i \, p_i \log p_i,$$

where the logarithm is to the base two. It is obvious that when perfect learning occurs, p_i for the correct choice is 1.00 and the probabilities for the other choices are zero. The logarithm of 1.00 is zero and there is no longer any uncertainty. Thus, U(x,y), the uncertainty at each trial is an estimate of how much is yet to be learned (or transferred). The original uncertainty less U(x,y) is the amount of information transferred. It is evident, therefore, that each treatment condition had the same amount of information to transfer initially. Furthermore, those subjects in the 1.5-second presentation rate were being asked to transfer the information at a rate twice as high as the subjects in the three-second presentation rate. The U(x,y) values for each item length by presentation rate treatment condition is shown in Table VIII by trials. The data are presented graphically in Figure 3.

The trends are quite clear that there is no large difference in the amount of information processed by any item-length condition within each presentation rate. It appears, however, that the 4-item, 1.5-second rate was at or close to the channel capacity, since negligible amounts of information were transferred. The uncertainty remaining at trial six, averaged over the 1.5-seconds presentation

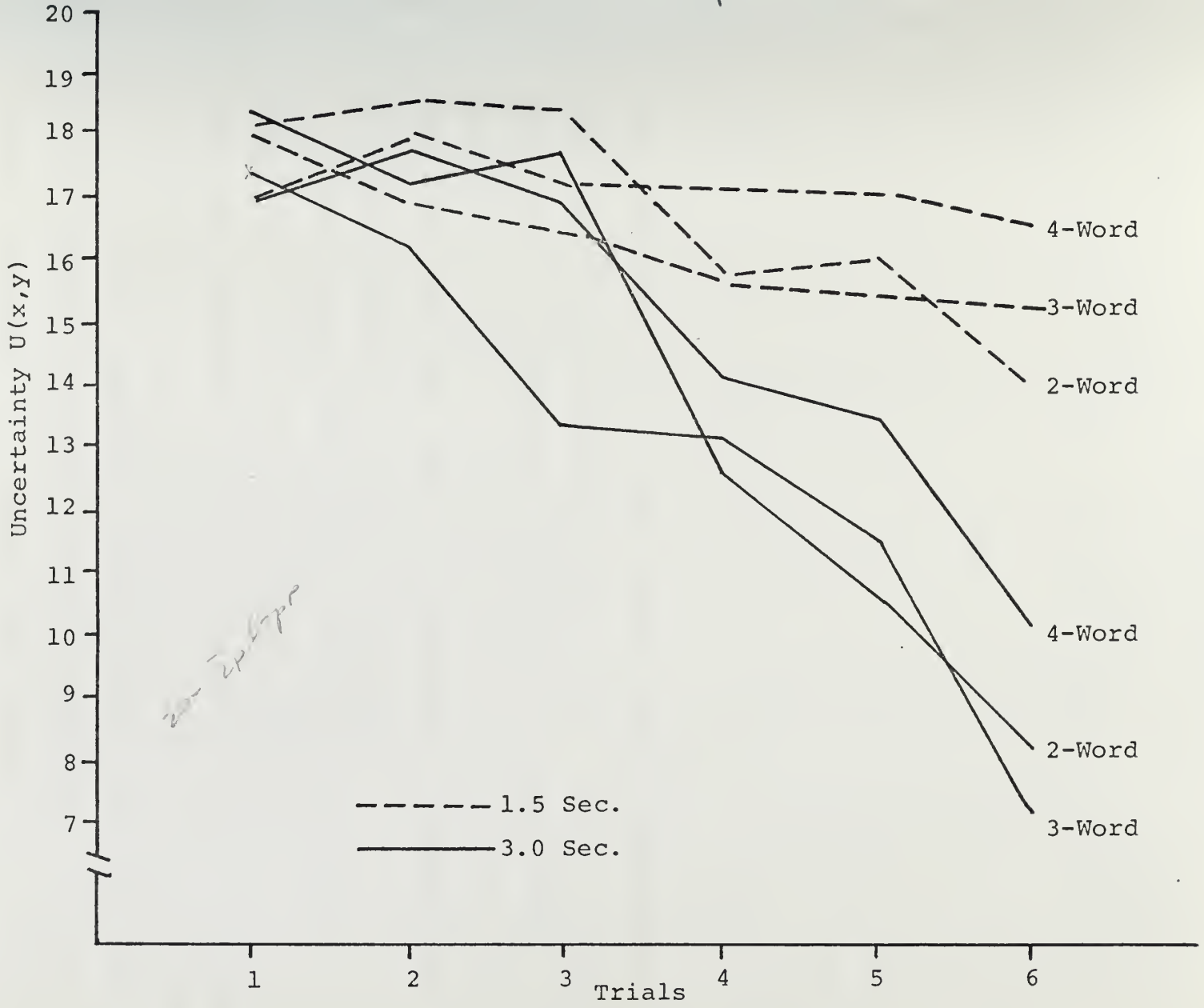

Figure 3. Uncertainty Remaining per Trial for Each Presentation Rate by Item Length.

TABLE VIII

UNCERTAINTY REMAINING PER PRESENTATION RATE OVER TRIALS

Trial	4-Words		3-Words		2-Words	
	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.	1.5-Sec.	3-Sec.
1	16.9	17.0	18.2	17.5	18.2	18.4
2	18.0	17.8	16.9	16.3	18.6	17.4
3	17.3	16.9	16.5	13.3	18.4	13.0
4	17.1	14.1	15.6	13.2	15.9	12.6
5	17.1	13.5	15.6	11.5	16.0	10.7
6	16.6	10.3	15.0	7.1	14.0	8.2

rate treatments was 15.2 bits and the amount remaining for the three-seconds treatments was 8.4 bits. Thus, it appears that the rate differential demanded by the experimental conditions is quite clearly apparent in the results. It should be noted that there is considerable information yet to be transferred at the end of six trials.

A comparison of the percent correct and information transferred measures is presented in Figure 4 for the 3-seconds presentation rate by item-length. The differences in elevation of the curves within the percent correct curves is, as would be expected, much greater and consistent than in the information transfer curves. The percent correct curves show (albeit not clearly) the monotonically rising, negatively accelerated curve typical of learning curves.

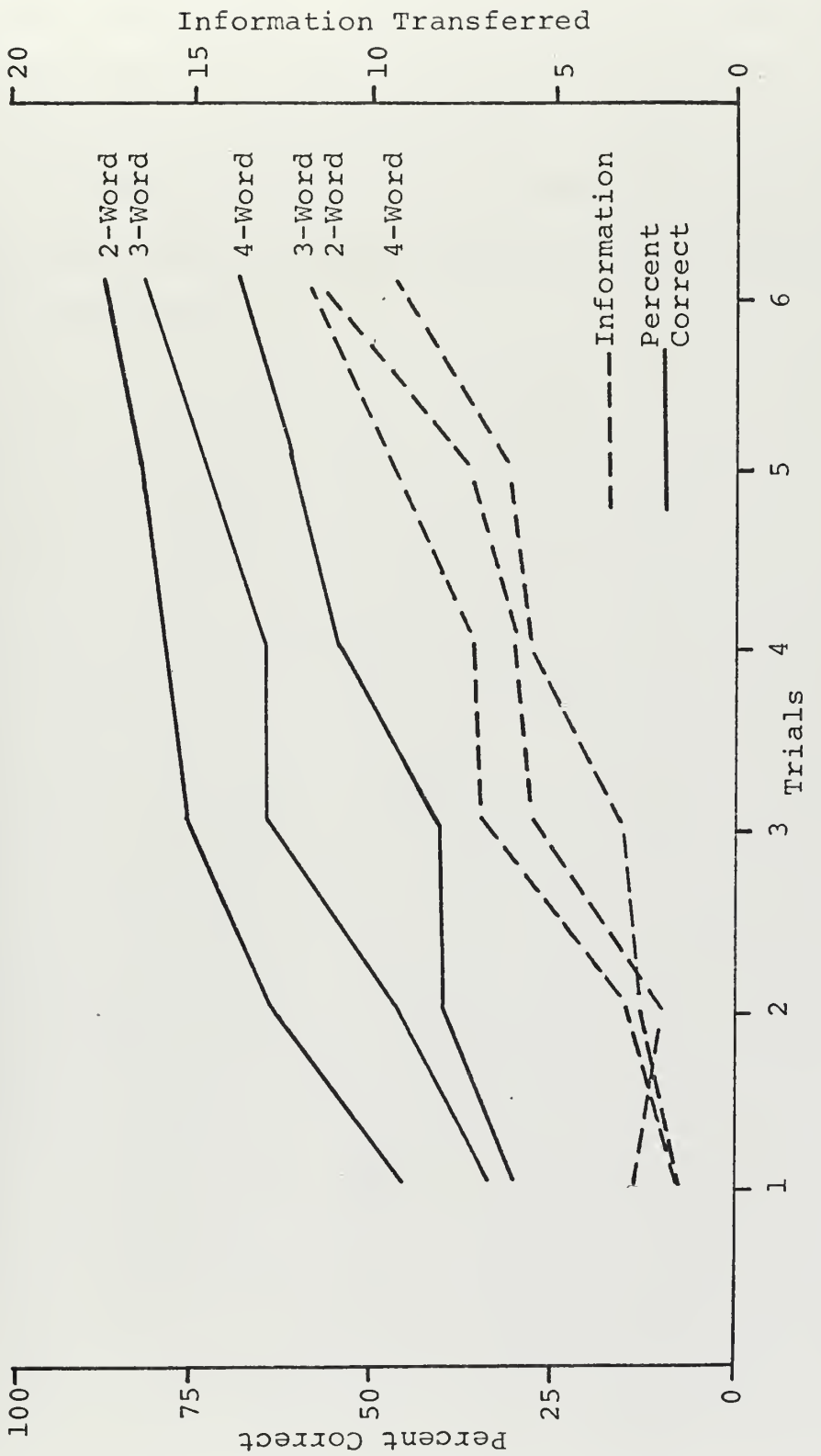

Figure 4. Information Gained per Trial Versus Percent Correct per Trial for 3-Second Presentations.

There is a trend in the information transfer curve for positive acceleration. The reason for the difference is evident in the fact that, with learning reaching the 75 percent correct point (and beginning to be constrained by the 100 percent ceiling), the information transferred has just passed the 50 percent mark of the total information to be transferred.

IV. DISCUSSION

This experiment has demonstrated that it is possible to quantify the difficulty of a VD item. The validity of the quantification was demonstrated by creating lists of equal workload but different in lengths and containing items differing in difficulty. The results were generally consistent with the equal workload quantifications. Moreover, the lists were processed at two rates, one twice as fast as the other, making the work/rate condition twice as high for the groups with short processing times. Again, the results showed that the differential in work output (information transferred) was close to a factor of two. Finally, it was suggested that an information transfer analysis of VD learning might provide a more sensitive measure than the percent of correct responses because it approaches the ceiling in a slower, positively accelerated manner.

The results of the experiment are also consistent with expectations from frequency theory (Ekstrand, Wallace, and Underwood, 1966), in the following ways. First, it can be assumed that individuals in the 3-second presentation rate, who had 3-second response (and rehearsal) periods, had a greater opportunity to rehearse the correct response (RCR), once it had been identified. It should be mentioned that the 2-word groups had an advantage in this respect since an initial right or wrong (unreinforced) answer served to

identify the correct response. This may account for the slight superiority of the 2-word groups in the experiment. On the other hand, it should also be noted that these are assumptions and that there was no way within the design to determine to what extent RCRs were made by the subjects.

Closely associated with the foregoing observation is another based on frequency theory regarding the differential difficulty in learning the 2-, 3-, and 4-word items. Frequency theory would state that it was more difficult to establish a differential frequency for the correct response in those items with a greater number of choices. In the case of the 4-word items, for example, there would be no opportunity to establish a differential frequency for the correct response if a subject made three incorrect responses to the same item or two incorrect responses to two different items in the first five trials. Frequency theory, however, does not provide a quantitative measure of the relative difficulty of n-word items. The information value of a set of n-words in an item does provide a measure of this difficulty based on a similar concept of the probability of choice of any one word within the set. That is, the difficulty in establishing a relative frequency advantage for any one alternative is directly related to the information content of the item. For example, a 3-word item with one highly predominant choice (high background frequency) would not have as high an information value as a 3-word item in which the choices are apparently all equal (as in this

study). Accordingly, it is suggested that a fruitful arena of future research would be to attempt to analyze information transmission with items having unequal a priori distribution of choices.

APPENDIX A

SUBJECT'S INSTRUCTIONS

You are participating in a verbal discrimination experiment. You will be shown one series of either 2-, 3-, or 4-word items, one of which has been arbitrarily selected as correct. The list of words is 10, 12, or 20 items long and will be repeated in various orders for six trials. You will have 1.5/3.0 seconds to view the words. Subsequent to each word group, there will be a blank space of 1.5/3.0 seconds duration. It is your task to view the words and guess which one is correct. Once you have selected your word, announce it to the experimenter. If your response is correct, the experimenter will tell you that you are correct, otherwise no answer will be given your response. In each item, the correct response word will remain the same throughout the experiment.

APPENDIX B

PERCENT CORRECT RESPONSES PER SUBJECT OVER TRIALS

Subjects*	Trials 1	2	3	4	5	6
1	40	20	40	40	40	60
2	20	20	00	40	60	20
3	00	00	20	40	40	80
4	40	60	40	40	40	20
5	20	00	00	20	20	20
6	40	20	40	60	60	60
7	20	20	60	40	60	60
8	20	40	20	00	20	20
9	80	20	60	60	40	40
10	40	20	40	60	80	60

SIMILAR WORDS

1	40	20	40	40	40	40
2	20	20	20	20	40	20
3	20	40	00	40	00	20
4	20	40	20	20	40	60
5	20	80	100	60	60	60
6	60	40	60	40	60	20
7	20	20	60	20	40	40
8	00	00	20	20	40	00
9	20	00	20	40	00	00
10	20	20	00	20	20	60

DISSIMILAR WORDS

*Four-word treatment at 1.5 second presentation rate.

Subjects*	Trials 1	2	3	4	5	6
11	60	60	20	80	80	80
12	40	20	60	60	60	100
13	00	00	20	80	60	60
14	00	20	40	20	40	60
15	40	100	60	100	100	100
16	00	40	20	20	40	40
17	60	20	20	20	20	60
18	20	40	80	100	100	100
19	20	60	40	40	40	80
20	60	60	60	80	80	80

SIMILAR WORDS

11	20	20	20	00	40	20
12	20	60	40	60	80	80
13	20	40	40	60	40	80
14	40	20	20	00	40	20
15	20	40	40	60	80	80
16	20	60	20	20	40	40
17	40	40	60	40	40	80
18	00	40	60	100	80	100
19	20	40	40	40	20	40
20	60	40	20	80	80	80

DISSIMILAR WORDS

*Four-word treatment at 3-second presentation rate.

Subjects*	Trials 1	2	3	4	5	6
21	33	50	50	50	50	83
22	17	67	50	17	17	50
23	33	67	50	67	100	67
24	17	67	50	50	83	83
25	50	17	17	67	67	50
26	50	67	50	67	83	67
27	50	17	33	50	50	67
28	33	33	50	67	50	67
29	33	33	50	67	67	83
30	33	17	50	33	33	50

SIMILAR WORDS

21	17	50	50	17	83	50
22	17	17	33	83	17	67
23	33	67	00	33	00	50
24	50	67	67	67	50	67
25	17	17	33	67	33	33
26	17	17	17	67	33	33
27	33	50	33	33	67	67
28	33	33	50	50	33	50
29	50	50	50	100	83	83
30	67	50	50	67	50	67

DISSIMILAR WORDS

*Three-word treatment at 1.5-second presentation rate.

Subjects*	Trials 1	2	3	4	5	6
31	33	33	50	67	67	67
32	17	67	83	83	100	83
33	17	33	83	50	100	100
34	50	33	67	67	83	100
35	33	67	100	83	100	100
36	50	17	67	67	67	100
37	33	67	83	100	100	83
38	50	33	50	33	33	67
39	33	50	67	83	83	100
40	67	67	50	83	83	67

SIMILAR WORDS

31	00	33	50	50	67	50
32	17	67	83	33	17	67
33	17	67	50	83	67	67
34	17	33	17	50	33	50
35	33	50	100	67	83	100
36	50	00	17	67	67	83
37	50	67	83	83	83	100
38	17	17	67	67	67	83
39	67	50	67	67	67	83
40	50	50	67	00	67	100

DISSIMILAR WORDS

*Three-word treatment at 3-second presentation rate.

Subjects*	Trials 1	2	3	4	5	6
41	70	70	50	100	60	80
42	50	80	70	70	80	70
43	40	70	70	40	60	60
44	70	60	60	70	90	70
45	50	60	80	80	50	90
46	30	60	60	80	60	70
47	50	60	70	50	70	100
48	60	40	30	60	30	70
49	60	30	50	70	80	70
50	40	70	60	90	90	80

SIMILAR WORDS

41	30	30	30	50	60	50
42	40	50	60	60	60	90
43	30	80	40	60	60	80
44	50	60	50	70	80	100
45	70	50	60	80	70	80
46	50	30	60	20	80	70
47	50	40	80	80	80	90
48	60	50	60	40	60	60
49	30	70	20	60	70	70
50	40	10	40	80	60	70

DISSIMILAR WORDS

*Two-word treatment at 1.5-second presentation rate.

Subjects*	Trials 1	2	3	4	5	6
51	70	60	90	90	100	80
52	40	50	60	80	60	80
53	50	40	30	50	70	80
54	20	60	70	50	60	70
55	50	70	70	100	100	100
56	60	60	70	90	80	90
57	30	80	90	80	90	100
58	60	60	70	70	50	60
59	40	80	70	80	90	90
60	50	80	80	100	80	90

SIMILAR WORDS

51	30	50	90	80	90	100
52	70	60	80	80	90	100
53	50	80	70	70	80	80
54	50	60	60	70	80	90
55	30	90	90	100	100	100
56	50	70	80	70	80	90
57	50	70	100	100	100	100
58	40	40	70	70	80	30
59	50	30	100	80	90	90
60	50	90	100	90	100	100

DISSIMILAR WORDS

*Two-word treatment at 3-second presentation rate.

APPENDIX C

PERCENT CORRECT RESPONSES FOR CORRECT RESPONSE WORD (POSTERIOR DISTRIBUTION)

Response Word*	Trials 1	2	3	4	5	6
mother	10	00	10	60	50	70
door	00	30	00	50	30	20
eye	30	40	20	40	40	30
swim	50	10	60	20	50	30
yard	40	40	30	20	10	40
yellow	40	30	50	40	60	70
lake	50	30	50	50	50	30
cotton	10	20	30	10	40	20
cat	30	50	40	30	60	50
year	30	30	20	20	30	40

1.5-SECOND

door	50	30	60	70	30	70
cotton	30	20	40	40	70	50
cat	30	60	30	50	60	80
swim	10	60	40	40	50	40
yellow	30	40	50	80	90	90
lake	50	50	50	70	70	70
mother	00	30	20	40	60	90
eye	30	30	60	50	70	60
yard	10	30	20	60	60	70
year	40	60	40	60	70	80

3-SECOND

*Four-word treatment over both presentation rates.

Response Word*	Trials 1	2	3	4	5	6
door	20	10	50	50	40	50
brother	20	40	50	70	70	70
green	40	60	40	50	50	80
lake	40	50	10	40	20	60
cotton	50	70	80	60	60	80
apple	30	60	70	60	60	60
iron	30	30	20	50	60	50
eye	40	50	50	70	70	60
minute	40	30	50	50	70	80
hill	30	50	40	30	50	40
boat	40	40	30	60	40	60
nail	20	30	30	70	30	40

1.5-SECOND

eye	40	50	80	60	80	100
brother	50	50	80	90	100	100
green	20	50	70	70	90	100
apple	30	50	70	50	80	100
lake	40	50	30	40	60	80
minute	40	50	60	70	80	90
hill	30	30	50	80	70	80
door	10	20	50	40	40	50
nail	30	30	60	70	70	70
iron	30	60	60	80	60	70
boat	40	60	80	60	70	60
cotton	50	60	90	70	80	90

3-SECOND

*Three-word treatment over both presentation rates.

Response Word*	Trials 1	2	3	4	5	6
murder	30	30	60	60	80	90
apple	60	60	60	70	50	80
iron	60	50	50	60	70	70
tea	60	60	80	100	80	100
table	40	80	60	50	50	60
mother	30	80	80	100	100	90
cat	40	60	60	70	90	80
eye	50	60	70	80	60	90
foot	50	50	30	70	40	60
corn	80	60	50	50	30	70
juice	80	70	60	80	90	90
book	40	30	60	40	60	60
nail	40	60	50	40	70	80
temple	30	50	30	70	80	90
cotton	50	30	40	60	50	80
bus	20	40	40	60	40	40
water	40	50	30	50	70	770
car	60	50	60	70	60	70
red	70	50	80	80	90	90
hour	40	60	50	30	60	60

1.5-SECOND

*Two-word treatment over 1.5-second.

Response Word*	Trials 1	2	3	4	5	6
foot	50	80	50	60	80	70
eye	60	80	80	80	80	80
tea	50	70	90	100	100	80
apple	60	50	70	90	100	100
iron	30	80	80	90	80	80
murder	10	50	90	80	90	100
book	40	70	90	50	90	80
juice	30	80	90	90	80	90
nail	50	60	90	70	90	100
temple	70	50	100	100	100	100
water	60	70	80	70	70	90
cotton	50	70	70	70	90	90
bus	40	60	60	70	80	100
mother	40	90	100	100	100	100
corn	80	50	50	90	80	90
cat	40	50	100	60	70	80
table	40	60	60	80	60	50
car	50	60	60	60	80	100
hour	50	30	40	70	50	80
red	30	80	70	90	100	100

3-SECOND

*Two-word treatment over 3-second.

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
INFORMATION TRANSFER IN 2-, 3-, AND 4-WORD VERBAL DISCRIMINATION

4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)
Master's Thesis; March 1971

5. AUTHOR(S) (First name, middle initial, last name)
Francis David Gray, Lieutenant, United States Navy

6. REPORT DATE
March 1971

7a. TOTAL NO. OF PAGES
45

7b. NO. OF REFS
7

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Naval Postgraduate School
Monterey, California 93940

13. ABSTRACT

Sixty Naval Postgraduate School students served in a verbal discrimination (VD) experiment with 2-, 3-, and 4-word items and presentation rates per item of 1.5 or 3.0 seconds. Half the items had similar and half, dissimilar words. Based on information theory, lists of different lengths were prepared for 2-, 3-, and 4-word items. The lists were equated for overall load at 20 bits of information. Performance was consistent with the equal-load hypothesis and a differential of two in the amount of information transferred was observed because of the rate factor. Analysis of variance of correct responses revealed significant effects for item length, presentation time, similarity, and trials.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
VERBAL DISCRIMINATION LEARNING						
INFORMATION THEORY						
HUMAN LEARNING						
ROTE LEARNING						

Thesis
G715 Gray
c.1 Information transfer
in 2-, 3-, and 4-word
verbal discrimination.
126483